FOREST RESTORATION IN A GLOBAL CONTEXT

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Abstract—Forest restoration on land cleared for agriculture is occurring around the world. Often land was abandoned because of infertility, frequent flooding, or other site limitations. In some countries, market forces or changing trade policies drive conversion of cleared land to plantations of exotic or native tree species. The objective of this paper is to introduce the special session on restoration of bottomland hardwoods by placing efforts in the Lower Mississippi Alluvial Valley into a global context. The challenges of forest restoration are surprisingly similar: overcoming site degradation, prescribing appropriate species, and applying cost-effective establishment methods. While plantation forestry remains the most effective approach to large-scale restoration, the trend is toward plantations that are more complex. This trend is characterized by more intimate association with other land uses, more diverse goals for species composition and vegetation structure in restoration planting, and more direct involvement by landowners in both the conception and implementation of restoration schemes. Benefits of restoration planting include reduced soil erosion; improved water quality; increased wildlife habitat; and increased supply of wood for fuel, lumber, and fiber. Increasingly, objectives of restoration planting include carbon sequestration.

INTRODUCTION

Forest cover has declined globally, from an estimated 6.1 billion ha of original forest extent to the present 3.45 billion ha (Krishnaswamy and Hanson 1999). The greatest loss in cover has occurred in Asia-Pacific, Africa, and Europe (all more than 60-percent loss of forest cover). Losses in North America are relatively low (25 percent), while Latin America (Central and South) has lost over 30 percent of the original forest cover. Nevertheless, the area in forest plantations is only 135 million ha, although increasing (Kanowski 1997).

Forest restoration on land cleared for agriculture, often termed afforestation, is widespread. Land may have been abandoned because of infertility, frequent flooding, or other site limitations. Today, as in the past, forest cover in populated areas is in dynamic equilibrium with land cleared for agriculture and taken for urban uses. Market forces, changing trade policies, or agricultural reforms drive conversion of cleared land back to trees. In Europe, for example, afforestation is a policy instrument to retire land from agriculture because of attempts by the European Union to reduce agricultural subsidies (Madsen and others 2001).

The objectives of this paper are to place the afforestation efforts in the Lower Mississippi Alluvial Valley (LMAV) into a global context by drawing parallels to work in other countries. The challenges of forest restoration in different countries are surprisingly similar (Kanowski 1997): overcoming site degradation/limitations, prescribing appropriate species, and applying cost-effective establishment methods. Plantation forestry is the most effective approach to restoration of large areas, and plantations that are more complex are recent trends.

TERMINOLOGY

What constitutes restoration can be confusing as the term is used indiscriminately. Changes in land cover and land use influence the dynamic relationship between degrading and restoring processes. If we consider the undisturbed, idealized natural mature forest as a starting point (fig. 1), then conversions to other land uses such as agriculture or pasture are through deforestation. Relatively frequent but moderate disturbance, such as plowing, herbicides, and grazing, maintain the nonforest cover.

Similarly, a change in both land cover and land use occurs when forests are converted to urban uses, flooded by dams, or removed along with topsoil/overburden in mining and extractive activities. Such drastic conversion usually involves severe disturbance and is maintained more or less permanently by structures more than by cultural activities (fig. 1).

Even-aged harvesting of mature forest in a sustainable manner is a change of land cover but not land use. A new, young forest will result from natural regeneration or by reforestation, i.e., planting trees in a cutover. Unsustainable harvesting such as high-grading degrades stand structure or diversity. Pollutant loading, outbreaks of insects or diseases (especially exotics), invasion by aggressive exotic plants, or disasters such as hurricanes or wildfires can also degrade forests. In all these instances, intervention to restore species diversity or stand structure can be termed rehabilitation (fig. 1).

Given sufficient time and the cessation of disturbances, agricultural land, as well as urbanized land, will revert to forest, if that is the potential natural vegetation as set by climate. Abandonment and reversion to forests, albeit

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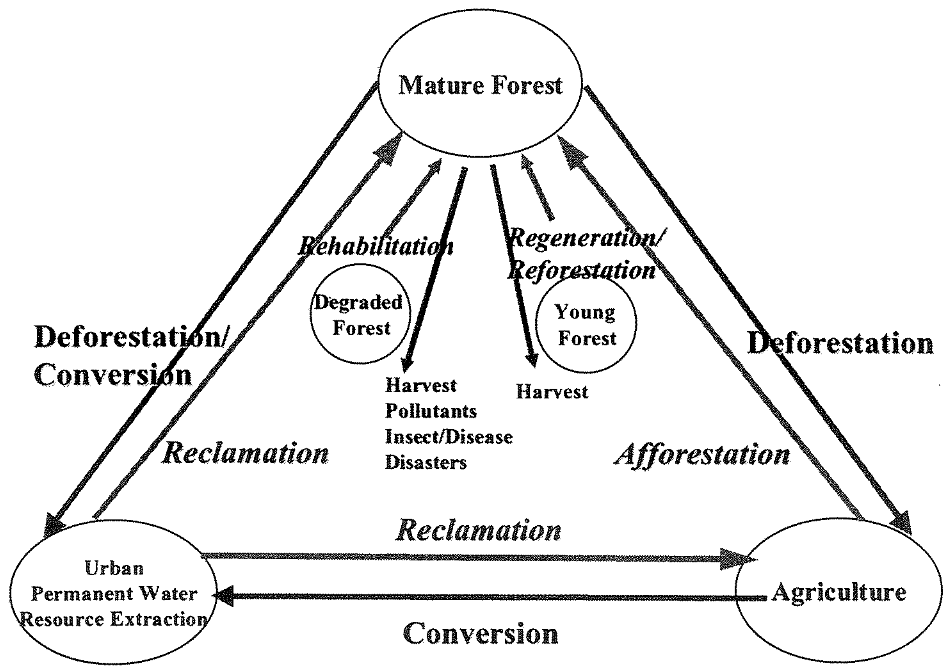

Figure 1—The terminology of forest restoration is best viewed in terms of land use as well as land cover change.

secondary or even degraded forest types, will occur gradually on a time scale of a few decades to centuries. Human intervention, however, can accelerate the reversion process. Afforestation of agricultural land may consist simply of planting trees, although techniques that are more intensive are available. Reclamation of urbanized land usually requires more extensive modification, which may include stabilization of spoil banks or removal of water control structures, followed by tree planting. Because severe degradation may limit the possibilities for reclamation, this process is sometimes called replacement (Bradshaw 1997).

Generally, restoration connotes some transition from a degraded state to a former natural condition. All the restorative activities described (reforestation, rehabilitation, afforestation, and reclamation) have been called forest restoration, although to the purist none would qualify as true restoration (Bradshaw 1997, Harrington 1999). In the narrowest interpretation, restoration requires a return to an ideal ecosystem with the same previous species diversity, composition, and structure (Bradshaw 1997) and, as such, is probably impossible to attain (Cairns 1986). Pragmatically, forest restoration can describe situations where forest land use and land cover are restored through the approaches of afforestation or reclamation.

COMMON CHALLENGES

Three steps are key to planning forest restoration: (1) understanding current conditions (as a starting point), (2) clarifying objectives and identifying an appropriate goal, and (3) defining feasible actions that will move toward the desired condition. In most cases, the silviculturist may choose among multiple silvicultural pathways toward the desired future condition. The choice of intervention affects the financial cost, the nature of intermediate conditions, and the time it takes to achieve the desired condition. It is imperative to make silvicultural decisions with clear objectives and with an understanding of a particular intervention's probable success.

Many examples of forest restoration can be classified as afforestation, reclamation, or rehabilitation (table 1). Three papers in this proceedings discuss in detail: bottomland hardwoods in the Southern United States (Gardiner and others 2001); broadleaves in the Nordic countries (Madsen and others 2001); and mangroves in Southeast Asia (Burbridge and Hallin 2001). The challenges of forest restoration are surprisingly similar: overcoming site degradation, prescribing appropriate species, and applying cost-effective establishment methods.

Overcoming Site Degradation

Previous land use may have degraded site conditions, especially for afforestation and reclamation projects. The specific conditions may vary from soil erosion or salinization, in which physical structure and chemistry of the soil are inhospitable to native trees, to lowered fertility from continuous cropping, e.g., Whalley 1988. In some cases, land becomes available for restoration because it is too infertile for agriculture. Existing forest stands in need of rehabilitation may have become degraded by past mismanagement, such as high-grading (removing all the biggest and best trees, leaving undesirable species or trees of poor form or low vigor), fire suppression, or holding water late into the growing season in green tree reservoirs. In other cases, hydroperiod alterations, hurricanes, severe windstorms, floods, or insect outbreaks may have degraded the stands, but not usually the site.

Table 1—Examples of forest restoration efforts in various parts of the world

Type of restoration	Region	Former condition	Restored condition
Afforestation	Lower Mississippi Alluvial Valley, USA	Agriculture	Bottomland hardwoods
Afforestation	Nordic countries	Agriculture	Hardwoods, sometimes Norway spruce
Afforestation	Tropical countries	Agriculture	Exotic and native hardwoods
Afforestation	Venezuela	Cerrado	Caribbean pine
Afforestation	Iceland	Eroded grazing land	Birch, lupine/birch
Reclamation	Everywhere	Mined land	Various
Reclamation	Asia	Shrimp ponds	Mangrove
Reclamation	Ireland	Mined peatland	Sitka spruce, various hardwoods
Reclamation	India	Saline and sodic soils	Eucalyptus spp., Acacia spp., other native spp.
Rehabilitation	Southeastern United States	Loblolly pine plantations	Longleaf pine woodlands
Rehabilitation	Interior Highlands, Southeastern United States	Shortleaf pine/hardwood forests	Shortleaf pine/bluestem grass woodlands
Rehabilitation	Central Europe	Norway spruce plantations	Oak or beech woodlands
Rehabilitation	England and Scotland	Spruce or pine plantations	Mixed woodlands

Site potential and extent of degradation set limits on what can be achieved by intervention. Site potential refers to the combination of relatively unchanging physical factors that affect species composition and stand vigor. Soil and landform characteristics determine moisture availability, aeration, and fertility. In wetland forests, hydroperiod characteristics are important (flood frequency, seasonality, duration, and depth). Site potential is not immutable, however, and can be influenced positively or negatively by changes in land cover or land use.

The cause and possible continuing problem of site or stand degradation should be identified. For example, alteration of a site by changed hydroperiod poses several questions. Can the hydroperiod be restored or the effects of alteration somehow mitigated? Should the restoration effort target a vegetation assemblage adapted to present hydroperiod and site conditions? Hydroperiod alterations caused by flood control projects, dams, or highway construction tend to be irreversible, at least in the short term. Flooding caused by beaver dams, however, can be reduced by removing the dam, but continued management of beaver population levels will be required to avoid recurring problems. The guiding principle should be to rehabilitate or restore in accordance with existing conditions, unless alteration is feasible, affordable, and within the control of the silviculturist.

Appropriate Species

Most restoration efforts favor native species, although some situations may use exotic species. In the Tropics, population pressures and land scarcity may require that restoration include species that provide early economic returns (Grainger 1988, Islam and others 1999, Parrotta 1992), and native forest species may be unsuited for degraded sites. Fast-growing exotic species alter site conditions enough for native species to thrive (Ohta 1990, Parrotta and others 1997). Nevertheless, lack of knowledge may lead to neglect of native species (Butterfield and Fisher 1994, Fisher 1995, Knowles and Parrotta 1995).

The perception of native species may be contentious. Some fast-growing species may be native but considered undesirable. Public citizens or government agencies may be averse to planting more pine [especially loblolly (*Pinus taeda* L.)] rather than broadleaves in the Southern United States, or eastern cottonwood (*Populus deltoids* Bartr. ex Marsh.) in the LMAV. Species under consideration may be native to the area but not to the site. In the LMAV, for example, extensive hydrologic changes have allowed planting of more oak trees (*Quercus* spp.) than were probably in the forests prior to European settlement (King and Keeland 1999). Even documenting the composition of the predisturbance forested landscape can be difficult and contentious (Hamel and Buckner 1998; Stanturf and others, in press).

An open question is to what extent should the manager today consider the possible effects of global climate change in choosing appropriate species to plant. The different global circulation models used by policymakers yield very different results for the Southern United States at the scale of the forest stand. Nevertheless, managers contemplating long rotations may want to hedge their bets by planting species adapted to drier conditions on upland sites. In bottomlands, the situation is more complicated. Rising sea level will not only inundate coastal forests but also cause a rise in the base level of rivers in the region, changing the hydroperiod of many sites. In some bottomlands, species tolerant of drier conditions would be warranted, but in those likely to be inundated later in the growing season, it is better to plant species that are adapted to prolonged soil saturation.

Effective Establishment Methods

Choosing species appropriate to the site and management objectives of the landowner is an important first step. Choice of stock type and proper handling are important, as well as adequate preparation of the site and postplanting practices, such as weed control. High survival is needed to insure adequate stocking (seedling density) and to minimize costs, especially where seedling costs are high, as in Scandinavia (Madsen and others 2001). Survival rates in industrial plantations, commonly 80 to 90 percent, set the benchmark. However, expecting such high survival in many restoration programs may be unreasonable, as the knowledge base may be insufficient due to limited research, practical experience, or available labor.

Vigorous growth of established seedlings is important to reach target stocking levels. Low-vigor seedlings may survive but are at greater risk of mortality from weed competition, mammal herbivory, or from insects and diseases. Vigorous growth will also speed the development of stand structure and canopy closure, important for achieving conservation and wildlife benefits (Stanturf and others, in press). On the other hand, cultural practices raise establishment costs and may not have a lasting effect on vigor (Stanturf and others 1998).

Planting density is an important decision because of the effect it has on meeting landowner objectives and minimizing costs. In order to determine an adequate stocking level given seedling survival, a simple approach is to calculate the initial density needed to achieve a future density. For example, the Wetlands Reserve Program (WRP) is a Federal incentive program in aid of farmers planting hardwoods on low-lying cropland (Stanturf and others 2000). The WRP target at age 3 is 309 stems per hectare, which is low for timber production and probably inadequate for wildlife (Stanturf and others, in press). Nevertheless, the agency will only share the cost for planting 750 seedlings per hectare with the landowner. Therefore, the initial stocking must allow for intensity of site preparation, planting efficiency, and species survival rates. Nuttall oak (*Q. nuttallii* Palmer) is the most commonly planted oak species in the LMAV and has an average operational survival rate of 60 percent for planted seedlings with minimum site preparation. For other oak species, however, survival is typically lower, 30 to 40 percent; and the target will not be met. In addition, inexperienced crews plant most WRP sites; and survival rates are below the operational benchmark, resulting in significant failures (Stanturf and others, in press).

PLANTATION FORESTRY AS A RESTORATION MECHANISM

The first step in restoring a forest is to establish trees, the dominant vegetation. Although this is not full restoration in the sense of Bradshaw (1997), this necessary step is far from a trivial accomplishment (Stanturf and others 1998; Stanturf and others, in press). Nevertheless, many people object to traditional plantations on the grounds of aesthetics or lack of stand and landscape diversity. The correct ecological comparison, however, is between plantations and intensive agriculture rather than between plantations and a mature natural forest (Stanturf and others, in press). All forest alternatives provide at least some vertical structure, increased plant diversity, and some wildlife and environmental benefits. Kanowski (1997) argued for a dichotomy in concepts between the traditional plantations organized for fiber production and more complex plantation forests that seek to maximize social benefits other than wood. Complex plantations that retain the economic and logistic advantages of simple plantations can meet restoration goals.

Advantages of Simple Plantations

Simple plantations are single purpose, usually even-aged monocultures that can produce as much as 10 times greater wood volume than natural forests (Kanowski 1997). Simple plantations, nevertheless, provide multiple benefits when compared to alternatives such as continuous agriculture; if managed well, they satisfy sustainability criteria. Significant advantages of simple plantations are that they easily can be established using proven technology, their management is straightforward, and they benefit from considerable economies of scale. If financial return is the primary objective of a landowner, simple plantations may be preferred and some restoration goals will be attained (Stanturf and others, in press). Nevertheless, complex plantations can be established that provide greater social benefit but at lower rates of return from timber production, possibly as little as 10 percent less (Kanowski 1997), or even at a net financial gain to the landowner, e.g., Stanturf and Portwood 1999).

Characteristics of Complex Plantations

Association with other land uses—Objections to plantations are often cast in terms of aesthetics. The sharp boundary between a plantation and other land uses is objectionable, as is the uniformity of trees planted in rows. In order to integrate the plantation with other land uses, the sharp edges of plantations can be softened by fuzzy or curved boundaries. Where plantations are on small farm holdings, agroforestry systems of intercropping can blend land uses. Forested riparian buffers are established in agricultural fields to protect water quality by filtering sediment, nutrients, and farm chemicals; and they bar easy access by livestock to stream banks. Riparian buffers add diversity to the landscape and serve as wildlife corridors between patches of fragmented forests. In floodplain landscapes such as bottomland hardwoods, areas of permanently saturated or inundated soil (respectively, moist soil units and open water areas) are common and diversify the interior of plantations.

Several options are available to overcome the uniformity of rows. Perhaps the simplest technique is to offset the rows. Uniform spacing between rows and between seedlings within a row is common, resulting in a square pattern. Rows can be offset to produce a parallelogram instead of a square. Alternatively, plantations can be planned with a recreational viewer in mind so that the view from trails and roads is always oblique to the rows, thereby escaping notice. At any rate, once the canopy reaches sufficient height that ground flora and midstory plants can establish, most plantations take on the appearance of natural stands, at least to the casual observer.

Species composition and vegetation structure—A more serious objection to plantations is the lack of diversity, in terms of species composition and vertical structure. Essentially, simple plantations are not as diverse as natural stands, at least for many years. Foresters have devised several methods to establish multiple species stands. For example, planting several blocks of different species in a stand, or even alternate rows of different species is possible and creates some diversity at the stand level. Distribution, however, remains more clumped than would be typical of a natural stand.

Other methods are available, including nurse crops of faster growing native species (Schweitzer and others 1997) or exotics (Ashton and others 1997, Lamb and Tomlinson 1994). In this approach, there is no intention of retaining the nurse crop species throughout the rotation of the slower growing species. (This could also be termed relay intercropping.) While the nurse-crop method has many advantages and in the short term provides species diversity and probably vertical structure, once the nurse crop is removed the residual stand may lack diversity. The challenge is to develop methods for establishing several species in intimate mixtures, such as would occur in a natural stand, but avoiding excessive mortality during the self-thinning or stem exclusion stage of stand development. Such methods must account for the growth patterns of the species, relative shade tolerances, and competitive ability.

Vertical structure is an important feature of forests for wildlife (DeGraaf 1987; Hamel and others, in press; Twedt and Portwood 1997). Early stages of stand development, whether in natural forests or plantations, are characterized by low light in the understory until crowns differentiate. In most restoration forests, little development of the understory and midstory occurs for many years. Annual disturbance while in agriculture removed buried seed and rootstocks of native plants, and low light levels in the young forest preclude understory development from invaders. To accommodate this deficiency, the manager can intervene to plant understory species; at present, little research affords guidance on methods, planting density, or probable success rates. As indicated above, relay intercropping provides vertical structure for a time. Natural dispersal into gaps can also encourage understory development, whether gaps are created by thinning or left during planting (Allen 1997, Otsamo 2000). The critical factor limiting understory development by natural invasion is whether there are seed sources for the understory plants within dispersal range (Chapman and Chapman 1999, Johnson 1988).

BENEFITS OF RESTORATION

The benefits of restoration are usually identified in terms of agency priorities or social benefits; seldom are the diverse objectives of landowners recognized. In most market economies where rights and obligations of ownership rest with private landowners, what is appropriate for public land may not be the most attractive restoration option for private landowners (Stanturf and others, in press). Nevertheless, there can be considerable overlap in the expected benefits to society and the affected landowner. The array of possible landowner objectives can be illustrated with a limited set of management scenarios from the LMAV (table 2). For simplification, three scenarios are presented: (1) short-rotation management for pulpwood or fuelwood; (2) a longer rotation typical of management for saw log production which is suitable for wildlife species that require complex vertical structure, such as certain neotropical migratory songbirds (Hamel and others, in press); and (3) an option termed green vegetation, which is essentially the no-management scenario. In the green vegetation scenario, species composition and stand structure are secondary concerns to removing land from active agriculture. This option meets the objectives of Federal programs, such as the WRP (Stanturf and others, in press). It may also provide habitat conditions for certain wildlife that otherwise would not occur on the landscape (Hamel and others, in press).

Table 2—Financial, recreational, and environmental benefits expected from three afforestation scenarios common in the Lower Mississippi Alluvial Valley, Southern United States

	Expected benefit level					
	Financial		Recreational		Environmental	
Scenario	Short term	Long term	Hunting	Nonconsumptive	Conservation practices	Land retirement
Short rotation (pulpwood, fuelwood)	High	High	High	Medium	Medium	No
Long rotation (timber, wildlife)	Medium	High	High	High	High	Medium
Green vegetation	Low to no	No	Low	Medium	Medium	High

Benefits are comprised of financial, recreational, and environmental outcomes. Because cash flow is important to many landowners, and the adjustment from annual to periodic income is often cited as a barrier to afforestation, financial benefits are considered as both short term and long term. Recreational benefits are hunting (typically for deer, turkey, and waterfowl) and nonconsumptive benefits, such as bird watching or hiking. Environmental benefits are separated into conservation practices, such as those installed to control soil erosion and protect water quality or enhance wildlife habitat, and land retirement, where there is no on-going management activity.

Financial Benefits

Financial returns from active management are substantial relative to the green vegetation scenario. Saw log rotations of high-value oak and green ash (*Fraxinus pennsylvanica* Marsh.) are expected within 60 to 80 years, with the first commercial thinning beginning in 20 to 30 years. Short-term financial returns from growing pulpwood-sized eastern cottonwood in the LMAV are realized within 10 years of afforestation (Stanturf and Portwood 1999). The short-term financial returns are low from plantations of other species. Nevertheless, other species can be combined with cottonwood in the nurse-crop technique to produce income for one or two pulpwood rotations, hence the medium rating. The green vegetation scenario, typified by the WRP plantings, provides no long-term income, as timber management is unlikely given the understocked stands that develop (Stanturf and others, in press). In the short term, there is income from the one-time easement payment made to the landowner (Stanturf and others 2000).

Other income can be realized by some landowners from hunting leases and potentially from carbon sequestration payments. In the Mississippi portion of the LMAV, hunting rights are leased for $7.50 to $12.35 per hectare per year. There is also a potential for considerable income to landowners from credits from carbon sequestration (Barker and others 1996). While there is considerable uncertainty over the accounting for carbon credits under the Kyoto Protocol, there seems to be agreement that afforestation will be eligible for offset credit (Schlamadinger and Marland 2000). Current projections in the United States for the value of a carbon credit are on the order of $2.72 to $4.54 per megagram of CO_2 sequestered, but the value is much higher in Europe. In Norway, for example, there is already a carbon tax on gasoline equivalent to $49 per megagram of CO_2 (Solberg 1997). Estimates from economic models suggest that a carbon tax of $27 to $109 per megagram of CO_2 would be necessary to stabilize global emissions at the 1990 level (Solberg 1997). Under these conditions, growing biomass for fuel would become an attractive alternative to fossil fuel because biofuels have no net impact on global carbon levels. At some time in the future, landowners in the LMAV may want to optimize carbon sequestration and biofuel benefits by planting willow (*Salix* spp.) on soils too wet for cottonwood.

Recreational Benefits

The primary recreational benefits assumed in the examples are from creating and enhancing wildlife habitat. Not all wildlife species require the same kind of habitat, so for simplicity the expected benefits can be separated into recreational hunting by the landowner (rather than lease fees) and nonconsumptive wildlife activities, such as bird watching or simply the existence value of wildlife to the landowner. Most species hunted in the LMAV benefit from a range of forest conditions and expected benefits are high in stands managed for pulpwood or saw logs. Low expected value is derived from the kind of open stands likely to develop from the green vegetation scenario (Allen 1997, King and Keeland 1999). Neotropical migratory birds and other birds are not uniform in their habitat requirements (Hamel and others, in press) but some will benefit from the kind of early successional habitat typical of short-rotation stands (Twedt and Portwood 1997), as well as the early successional herbaceous fields of the green vegetation scenario. Species of concern are of two kinds, those requiring the early successional herbaceous vegetation and those found in the kind of complex vegetation structure found only in older stands, which the saw log rotation may develop in time (Hamel and others, in press). Birds that use the intermediate conditions of stand development are probably likely to occur in developing stands for which the intended management purpose is sawtimber production.

Environmental Benefits

Water-quality benefits of afforestation accrue from reducing soil erosion (Joslin and Schoenholtz 1998), and filtering, retaining, and assimilating nutrients and farm chemicals from surface runoff and groundwater (Huang and others 1990). As Lockaby and Stanturf (2001) point out, however, typical restoration stands in the LMAV no longer experience the kind of flow-through hydrology of a riverine system; and the filtering action will be limited.

Greater water-quality benefit will be derived from forested riparian buffers. Planted forested buffer strips in an agricultural landscape are uncommon, although several studies have examined the filtering action of natural forested riparian zones (Cooper and Gilliam 1987; Cooper and others 1987; Lowrance and others 1983, 1984a, 1984b, 1986; Peterjohn and Correll 1984; Todd and others 1983). Comerford and others (1992) summarized these studies and concluded that buffer strips are quite effective in removing soluble nitrogen and phosphorus (up to 99 percent) and sediment. The efficiency of pesticide removal by forested buffer strips has been examined in some environmental fate studies that concluded that buffer strips 15 m or wider were generally effective in minimizing pesticide contamination of streams from overland flow (Comerford and others 1992). Recently, forested buffer strips in the LMAV became attractive financially to the landowner by a new incentive program (Continuous Signup/Conservation Reserve Program), which allows use of the cottonwood/red oak nurse-crop system.

CONCLUSION

Forest restoration, in the broad sense that encompasses afforestation, rehabilitation, and reclamation, is occurring throughout the temperate and boreal zones. Site conditions differ, native species are diverse, and the policy context in which restoration occurs varies. Nevertheless, the challenges faced by managers are similar: overcome site degradation, prescribe appropriate species, and apply cost-effective methods. Clarity of objectives is critical to designing a successful restoration program and diagnosis of site conditions and potential should guide intervention.

Knowledge and experience with establishing plantation for timber production can be used to efficiently restore large areas of agricultural land to forest.

While simple plantations have many financial and technological advantages, plantations that are more complex will be required in most countries. Aesthetics, species diversity, and the need to rapidly create vertical vegetation structure are some of the concerns that must be addressed.

The benefits of restoration should be viewed in comparison to the previous conditions of land cover and land use. In most cases, environmental benefits are immediate. Restoration forests can differ in functioning and management, according to the objectives of the landowner. There is usually considerable overlap between social and individual benefits. Even forests primarily managed for timber production provide environmental and recreational benefits to society.

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